The FLTSATCOM-C system is comprised of several subsystems to operate in various frequencies and services. The subsystem of interest for this report is employed in the space operations service for telemetry and telecommand operations in the 1760-1840 MHz and 2200-2290 MHz frequency ranges. The system's line diagram, which includes the up- and down-links with their respective operational frequency ranges, is shown in Figure 5-3. The telemetry/telecommand subsystem will be utilized on FLTSATCOM-C satellites to transmit tracking and telemetry data to and receive tracking and telecommand data from Air Force SGLS terrestrial installations.

The intended frequencies of operation for the telemetry link are SGLS Channel 11 at 2252.5 MHz (primary) and SGLS Channel 13 at 2262.5 MHz (backup). While, the intended frequencies of operation for the telecommand link are SGLS Channel 11 at 1803.760 MHz (primary) and SGLS Channel 13 at 1811.768 MHz (backup). The FLTSATCOM-C system is intended to eventually replace the older generations of the Navy's FLTSATCOM.

Defense Satellite Communications Systems (DSCS)

The DSCS is an integral component of the global Defense Communications Systems (DCS). It is designed to provide vital command, control, and communications services to the U.S. and Allied Forces throughout the world by means of satellites. The DSCS provides reliable, large-capacity, quality communications capability in support of peacetime, contingency, and war operations. The DSCS provides the primary transmission path for much of the DOD's highest priority communications. It also offers a means of restoring other DCS transmission systems that may become inoperative. It is engineered and configured to satisfy validated Worldwide Military Command and Control System requirements. A unique feature of the DSCS is its capability to extend communication services to remote locations not adequately served by other means. The satellites were designed to operate in conjunction with a variety of earth station types, including fixed, land transportable, shipboard, and airborne, that use either frequency division, time division, or spread spectrum multiple access.

The DSCS space segment consists of both DSCS II and DSCS III satellites in a constellation that is configured to provide maximum mission support. The constellation normally consists of five operational satellites along with in-orbit spares. DSCS III satellites are intended to replace DSCS II satellites, and this replacement has already been accomplished in the Atlantic and East Pacific Ocean regions. An operational configuration of a DSCS III satellite network is illustrated in Figure 5-4. A total of 14 DSCS III satellites will be needed to maintain a fully operational system through the year 2001. There is an ongoing effort within the Air Force and

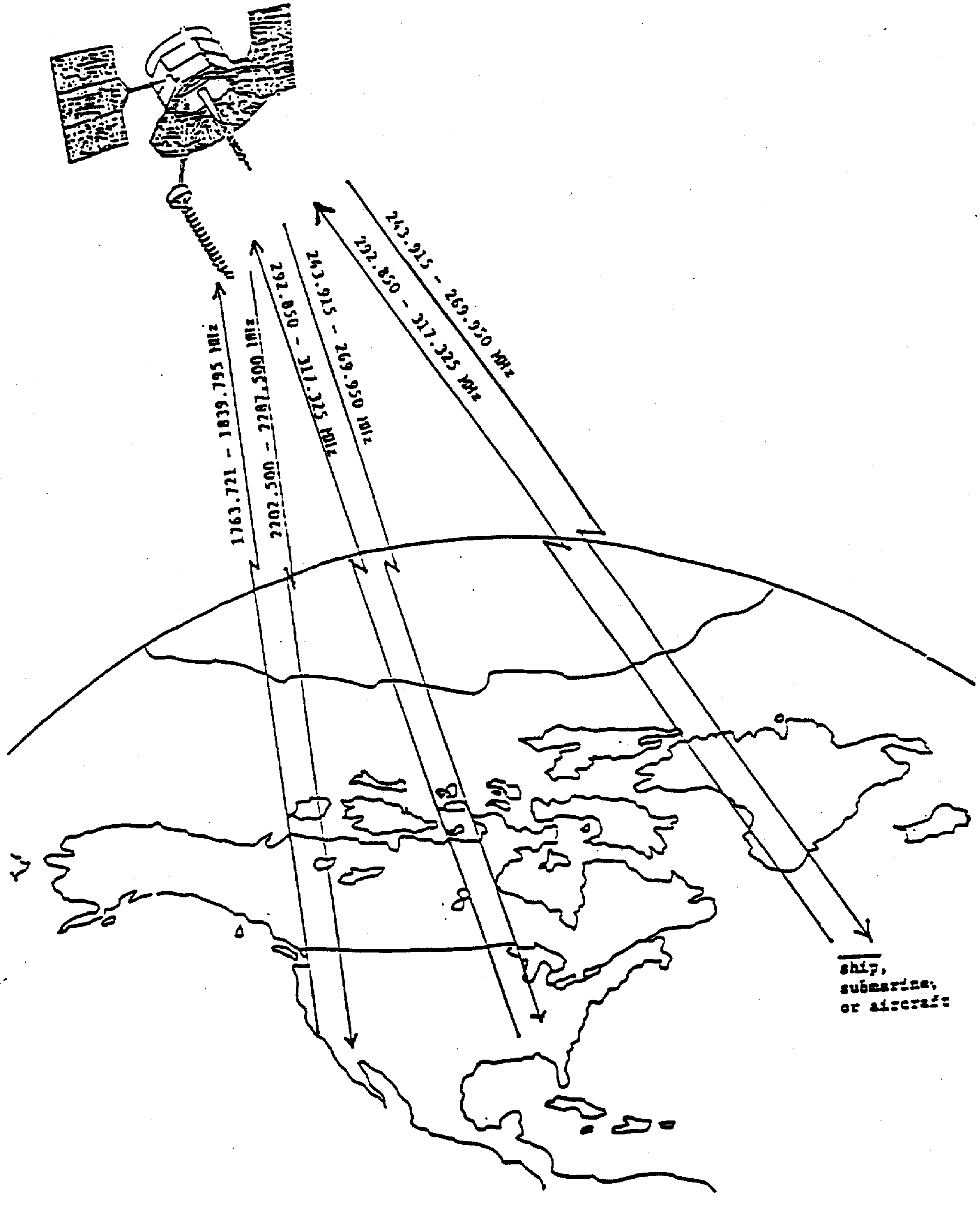


Figure 5-3. FLTSATCOM-C line diagram.

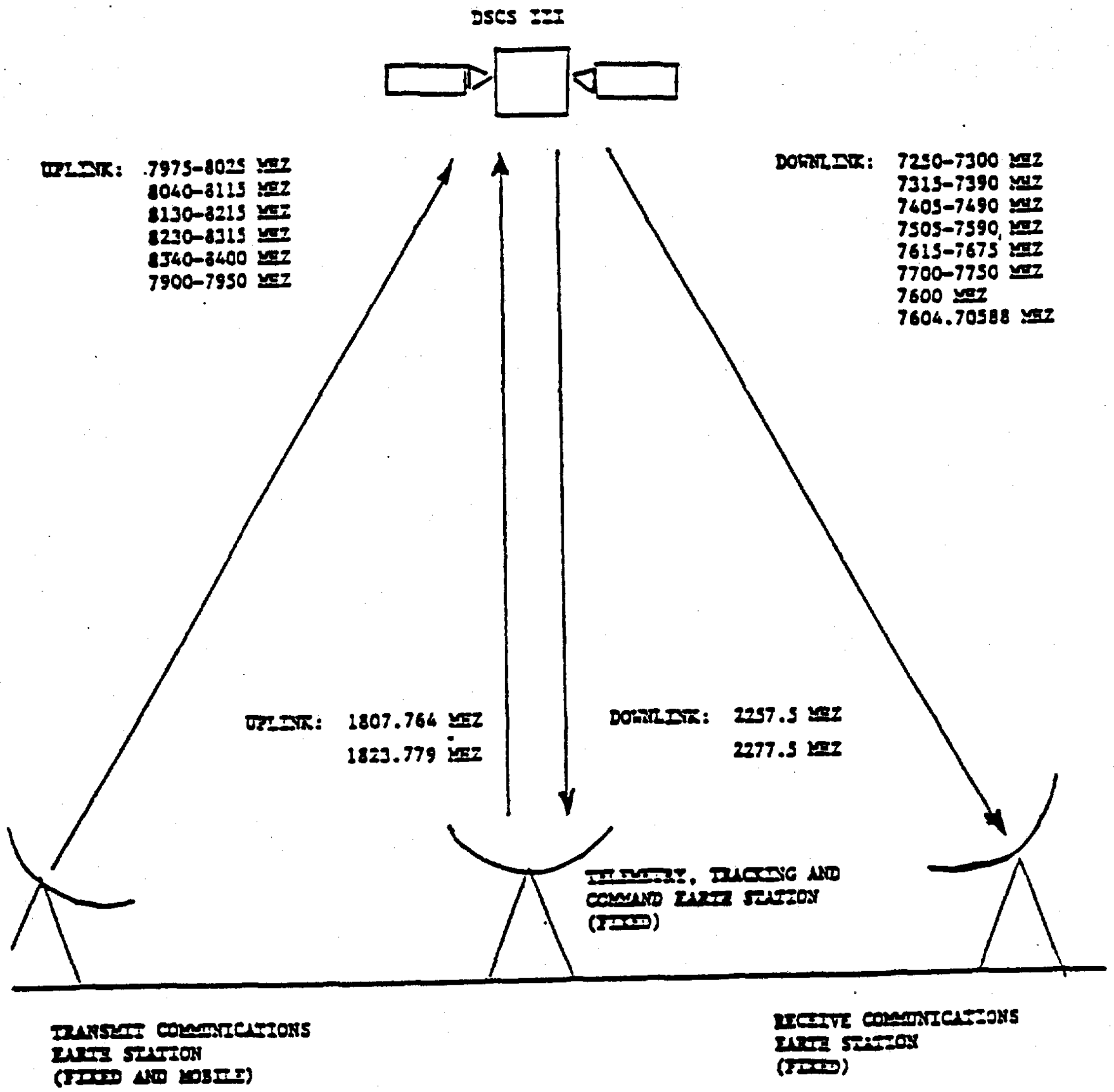


Figure 5-4. Operational configuration of the DSCS-III System.

Defense Information System Agency to upgrade the system including the addition of a 44/21 GHz capability.

Each DSCS satellite has a telemetry, tracking, and command (TT&C) subsystem that provides formatting, encryption, and transmission of satellite telemetry; reception, filtering, and a ranging signal; and reception, decryption, and decoding of commands. The TT&C subsystem includes independent redundant 1.8/2.2 GHz links. The 1.8/2.2 GHz links are primarily used by the AFSCN for normal command and control of the DSCS satellites support subsystems and during spacecraft anomalies. This TT&C capability is also used as a backup for communication payload control. The DSCS 1.8/2.2 GHz links are supported by the AFSCN-SGLS.

Navstar Global Positioning System (GPS)[8]

The GPS is a space-based radio positioning, navigation, and time-transfer system that will replace many existing radionavigation systems such as; Loran-C, Omega, TACAN, and others. It provides highly accurate three dimensional position and velocity information along with coordinated universal time to an unlimited number of suitably equipped users under all weather conditions, continuously, anywhere on or near the surface of the Earth. The planned GPS operational constellation is a 6-plane, uniform 21-satellite configuration plus three active spares.

The system consists of three major segments: a space-segment - satellites that transmit radio signals; a control segment - ground-based equipment to monitor the satellites and update their signals; and a user segment - equipment which passively receives and converts satellite signals into positioning and navigation information. Each satellite transmits on L_1 (1575.42 MHz) and on L_2 (1227.6 MHz) navigation signals. Superimposed on these signals will be navigation and system data, including a predicted satellite ephemeris, atmospheric propagation correction data, satellite clock error information, and satellite health data. A third signal (L_3) at 1381.05 MHz is used to relay nuclear detonation detection information gathered by sensors on the GPS satellites. Government Footnote G114 allows this function to be performed in the fixed- and mobile-satellite services in the downlink direction.

The control segment includes a master control station (MCS) and a number of monitor stations and ground antennas located throughout the world. It consists of equipment and facilities required for satellite monitoring, telemetry, tracking, commanding, and control,

8. Wooden, W., *Navstar Global Positioning System*, Defense Mapping Agency, Los Angeles, CA, 1985.

uploading, and navigation message generation. The monitor stations passively track the satellites, accumulate ranging data from their signals, and relay them to the MCS where they are processed to determine satellite position and signal data accuracy. The MCS updates the navigation message of each satellite and relays this information to the ground antennas which transmit it to the satellites. The ground antennas are also used for transmitting and receiving satellite control information. The control information, as well as updated messages, are relayed via the uplink (1783.74 MHz) and downlink (2227.5 MHz) frequencies.

The user segment includes low, medium, and high dynamic receivers designed to different requirements of various users. The user equipment is designed to receive and process signals from four orbiting satellites either simultaneously or sequentially. The processor in the receiver then converts these signals to three-dimensional navigation information in World Geodetic System coordinates. Positioning data are presented on a display unit in any other coordinate system desired by the user. In addition precise time information is available for use in the host vehicle.

Both the military and civilian users are the beneficiaries of the GPS. Figure 5-5 shows some of the many potential applications of the system.

Space Test Satellite (P80-1)

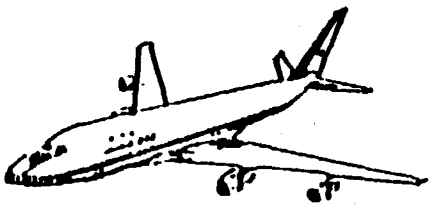
The USAF P80-1 satellite, launched in late 1989, occupies a 740 km circular orbit inclined 72.5°. The space test satellite is a programmed DOD Space Transportation System (Space Shuttle) payload that is intended to conduct experiments which include the use of an infrared telescope and lasercom.

The uplink commands and ranging signals are received from ground tracking stations (i.e., AFSCN) at 1771.729 MHz with a 4 MHz of bandwidth. The downlink transmissions of telemetry data are conveyed through two discrete frequencies at 2207.5 MHz (carrier II) and 2212.5 MHz (carrier I) using a 3M00G2D emission scheme. These downlinks can relay either real-time experiment data or recorded experiments, and spacecraft health and status data on command.

CRRES/P86-1 Satellite System

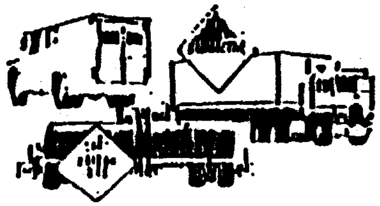
The Combined Release and Radiation Effects Satellite (CRRES), also known as the P86-1 satellite system, was a joint NASA and USAF project. As expected, the Air Force was responsible for the tracking, telemetry and command support.

Airborne



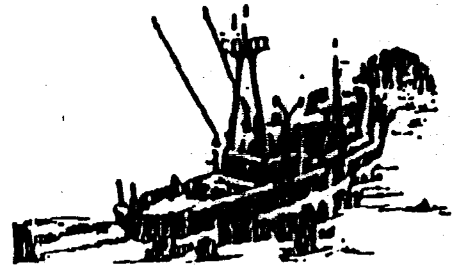
- Approach/Landing
- Oceanic En Route
- Domestic En Route
- Terminal
- Remote Areas
- Helicopter Operations

Land Navigation



- Vehicle Monitoring
- Schedule Improvement
- Minimal Routing
- Law Enforcement

Maritime Navigation

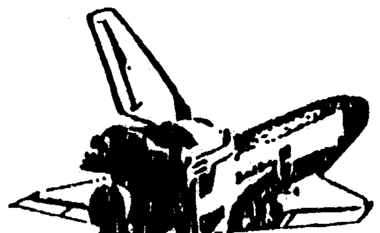


- Oceanic
- Coastal
- Harbor/Approach
- Inland Waterways

Static Positioning/Timing

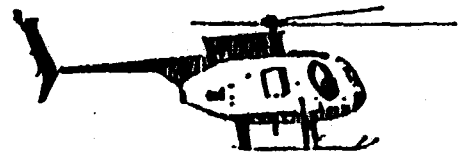
- Offshore Resource Exploration
- Hydrographic Surveying
- Aids-to-Navigation
- Time Transfer
- Geophysical Surveying

Space



- Launch
- In Flight/Orbit
- Reentry/Landing

Search & Rescue



- Position Reporting & Monitoring
- Rendezvous
- Repeatability of Position
- Coordinated Search
- Collision Avoidance

Figure 5-5. Some of the potential applications of the GPS.

The CRRES performed experiments in low Earth-orbit (LEO) in the ionosphere, conducted basic plasma physics research by the release of chemicals. After its transition to a geostationary transfer orbit (GTO), the CRRES mapped and characterized the dynamic behavior of the radiation belts and studied solar flare energy conversion and particle acceleration mechanisms through the identification of isotopes. The CRRES was designed for shuttle launch, however, it was modified for the mid-1990 launch aboard an Atlas-Centaur Booster.

The telemetry data were transmitted at 2222.5 MHz using a 5M00G7W emission type and a power of 10 watts (GTO) and were received at the AFSCN sites. The uplink command and control signals were received at 1779.736 MHz with a 4M00G7W emission designator.

Defense Meteorological Satellite Program (Block 5D)

The Defense Meteorological Satellite Program (DMSP) collects and disseminates various meteorological and other environmental data to worldwide DOD units. This information is also provided to the National Oceanic and Atmospheric Administration (NOAA). The fifth satellite of the Block 5D-2 series was launched in December 1991. These polar-orbiting satellites provide meteorological, oceanographic and ionospheric measurements for the DOD.

Array of Low Energy X-rays Imaging Sensors (ALEXIS)

The system is projected to measure x-rays and background noise in spaces using an array of low energy x-ray imaging sensors. The satellite is expected to be launched upon the new air-launch vehicle Pegasus and will be put into a 740 to 835 km orbit with a 90° inclination. In contrast with the other satellite networks discussed above, ALEXIS will be utilizing only one earth station located at Los Alamos, NM. The uplink transmission will be carried at 1774 MHz with 50 watts of power, a 13 dBi antenna gain, and a bandwidth of 10 kHz. The downlink signal will have a broader bandwidth of 1.5 MHz, however, with a lower power and antenna gain of 10 watts and 2 dBi, respectively. The downlink signal will be transmitted at 2260.5 MHz. Although the system is under the auspices of the AF, DOE intends to implement ALEXIS to gather data in support of the U.S. Treaty Verification Program.[10]

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[10] Letter with Enclosure from Robert M. Lewis, DOE, to E. Dinkle, Executive Secretary IRAC, IRAC Document 26848/1, May 16, 1990.

The system is projected to have a 5-year lifetime. The activation date was planned for January 1991 and a termination date of January 1996.

Inertial Upper Stage (IUS)

The IUS is an upper stage launching system which is used with either the Space Shuttle Orbiter or the Titan 34D launch vehicle to deliver satellite payloads to earth orbits higher than achievable by the Shuttle and Titan systems. The IUS is initially activated after being placed in low-Earth orbit (approximately 300 km) and is deactivated once it achieves final payload orbit insertion. Maximum IUS operational time per mission is expected to be on the order of eight hours when delivering a payload from the shuttle to geostationary orbit.

The frequencies 2212.5 MHz, 2217.5 MHz, 2232.5 MHz, and 2272.5 MHz are being used to transmit telemetry signals to either the shuttle, an advanced range instrumented aircraft (ARIA) or cooperating AFSCN earth stations. Command signals from either the shuttle or the SCF will be received at 1771.729 MHz, 1775.732 MHz, 1787.744 MHz and 1819.775 MHz.

IUS telemetry transmissions will use a 10 watt transmitter. Depending on the mission either a 1.3 dBi (low gain) or 6 dBi (medium gain) transmit antenna will be used. On shuttle launched missions, both antennas are used with the low-gain antenna to be used until final orbit altitude is reached. Titan 34D missions will be equipped with only the medium gain antenna.

Instrumented Test Vehicle (ITV), SGLS

The system provided uplink and downlink communications between the AFSCN-SGLS ground stations and the ITV earth orbiting vehicle. The ITV contained two subsystem elements: Miss Distance Indicator (space-to-space) and SGLS (Earth-to-Space and Space-to-Earth). The ITV communicated with the SGLS ground stations over two standard uplink and downlink frequencies of 1771.729 MHz (channel 3) and 1819.775 MHz (channel 15), and 2212.5 MHz (channel 3) and 2272.5 MHz (channel 15), respectively. The launch site of ITV vehicles was located at Wallops Island, VA.

P78-2 Satellite System

The system transmits telemetry data from the P78-2 satellite to the AFSCF ground stations and receives command and control signals from these stations. The P78-2 was launched in January 1979 and the termination date is unknown.

FIXED SERVICE

Point-to-Point, Line-of-Sight

This functional class of systems represents the largest group of assignments (4847) in the band. This band has become the principal band to support medium capacity fixed microwave links (typically 24 to 300 voice channels) for the Federal Government. The links are typically used for multichannel telephony, command, and telemetry as well as a limited use of video relay. Applications include law enforcement networks, backbone trunking systems as well as control links for various power, land, and water management systems. Circuits are usually of one to three hops with some being as long as seven hops.

Many agencies employ these fixed links in this band using equipment from a variety of manufacturers. With few exceptions, the equipment used is commercial equipment purchased off-the-shelf which can be crystal tuned to any frequency across the 1700-2400 MHz band. Typical parameters include a 1 to 40 Watt transmitter, 22-33 dBi antenna gain and bandwidth of 800 kHz to 10 MHz. Most of the systems operate on a continuous basis with many requiring a very high reliable service due to the criticality of the functions such as nuclear plant or dam control.

Bands that are available to all Government agencies to support point-to-point communications are as follows:

Low Capacity (1-24 Channels)	931-934 MHz 941-944 MHz
Medium Capacity (24-96 channels)	1710-1850 MHz 2200-2300 MHz 4400-4490 MHz
High Capacity (96 or more)	7125-8500 MHz 14.4-15.35 GHz

Figure 5-6 shows the Coast Guard Vessel Traffic System at New York as a representative network showing the interconnection of the various capacity links.

The timing distribution systems are a specialized class of point-to-point networks. These are employed by the military at various test ranges for distributing a common time reference signal to several test locations. In a typical configuration, the timing signal is transmitted omnidirectionally from a central location to several remote sites each of which employs directional antennas. Transmitter powers of 25 to 400 Watts and bandwidths of 0.2 to 1 MHz are typical. The equipments used for these systems are often modified versions of the lower power commercially available equipments just discussed. Approximately six assignments are recorded for these operations.

Tactical and Training Radio Relay

There are 232 noted assignments from the U.S. Army and Air Force for radio relay operations for tactical command and control communications which are currently registered in the 1710-1850 MHz band. The principal characteristics that distinguish these radio relay operations from the fixed point-to-point links lie in their transportability and the channelized tuning capability, both basic principles of tactical operations. Radio relay connectivity links various subordinate, lateral and strategic headquarters, functional and component nodes into an integrated area-wide network. Linkage through line-of-sight radio relay is critical to this integrated joint and allied network. The assignments indicate a variety of equipment which indicate a mixture of use of older versions and new systems operating under these assignment authorities. Older radio systems are replaced and phased-out according to the Army life cycle plan. The requirement and use of the frequencies does not decrease with fielding of new equipment.

Temporary and permanent assignment policy may tend to show trends which indicate a decrease in the number of assignments for radio relay. The policy of not registering assignments which are less than a year, limits the actual assignments count made in this band. Typical command and control network assignments are in the 200 links range for each large Army post or training area with smaller posts varying less than the larger posts.

The laws of physics and current technology make this frequency band as the optimum band in satisfying command and control network connectivity which primarily emphasize maneuverability, flexibility and dispersion. Principal among these requirements are lightweight and transportable, ease of speed of installing, operating and breaking down systems, bandwidths

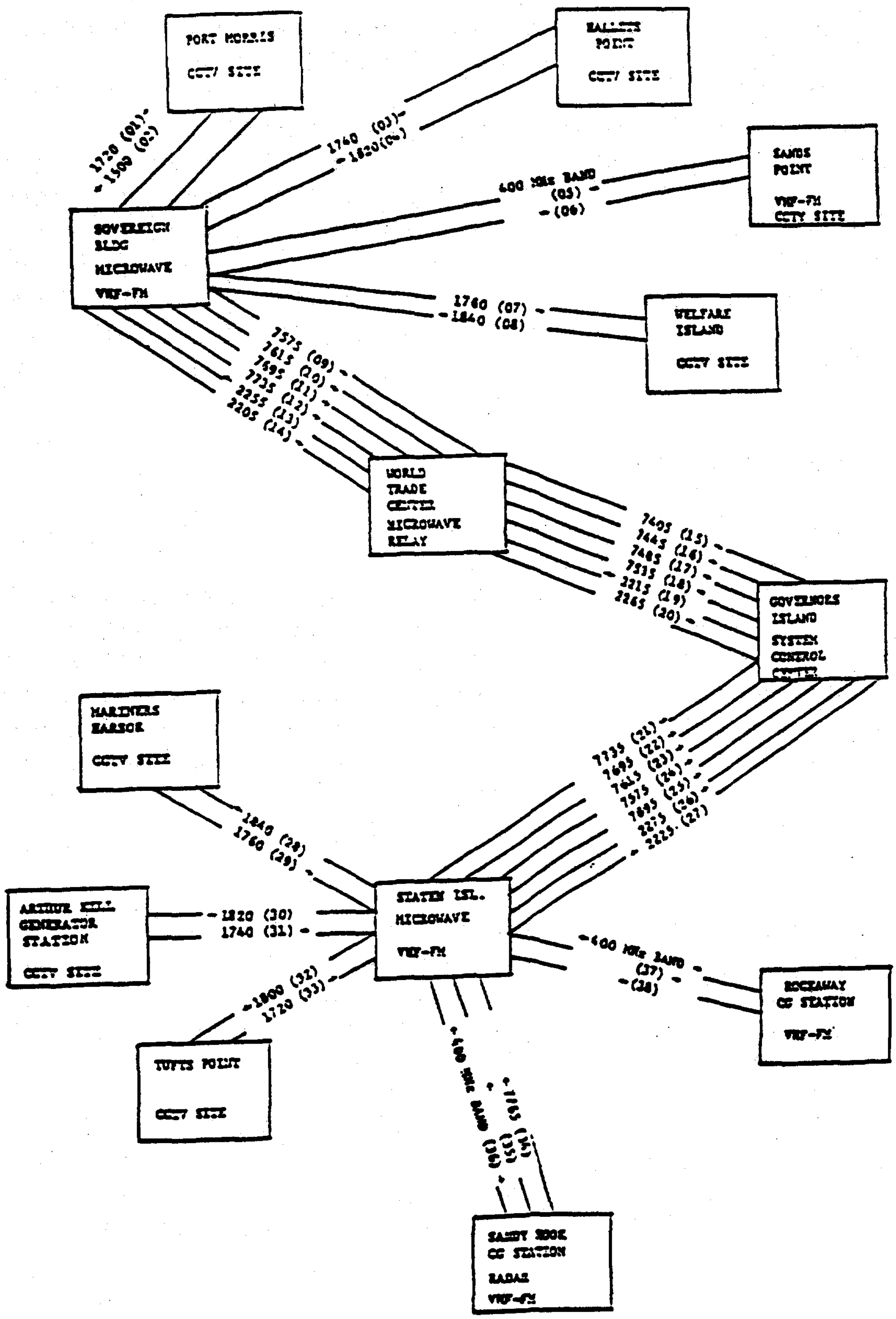


Figure 5-6. U.S. Coast Guard Vessel Traffic System at New York.

to support channel capacity, line-of-sight ranges, minimum power requirements and interoperability and compatibility on the air/land battlefield.

A summary of some of the basic operational characteristics of selected radio relay equipment operating in this band is shown in TABLE 5-5.

TABLE 5-5

BASIC OPERATIONAL CHARACTERISTICS OF SELECTED TACTICAL AND TRAINING RADIO RELAY EQUIPMENT OPERATING IN THE 1710-1850 MHz BAND

Equipment	Power (Watts)	Channel Capacity	Emission Type
AN/GRC-50	20	4-12	1M20F9W
AN/GRC-103	25	24	500KF9W
AN/GRC-226	5	16,32,64	1M10F9W

Air Combat Maneuvering Instrumentation and Tactical Aircrew Combat Training System

These systems employ both fixed and aeronautical mobile components and are discussed under the latter heading.

Fixed Security Surveillance Systems

Paragraph 4.2.2 of the NTIA Manual allots fixed security surveillance systems on a secondary basis in the 1710-1850 MHz band. The specific frequencies allotted include 1720, 1740, 1760, 1780, and 1800 MHz. In the GMF two Air Force Security Systems were identified. The first, Missile Launch Surveillance and Alarm System, operates at 1720 MHz with 2.2 watts of power, 18 dBi antenna (transmit and receive) gain, and an emission bandwidth of 15 MHz. This system is utilized at Whiteman, Missouri and Minot, North Dakota. The second, Movement Detection System, also operates with the same frequency, antenna gain, and emission bandwidth. The antenna output power, however, is 2.5 watts. The assignment for this system is for Ellsworth, South Dakota.

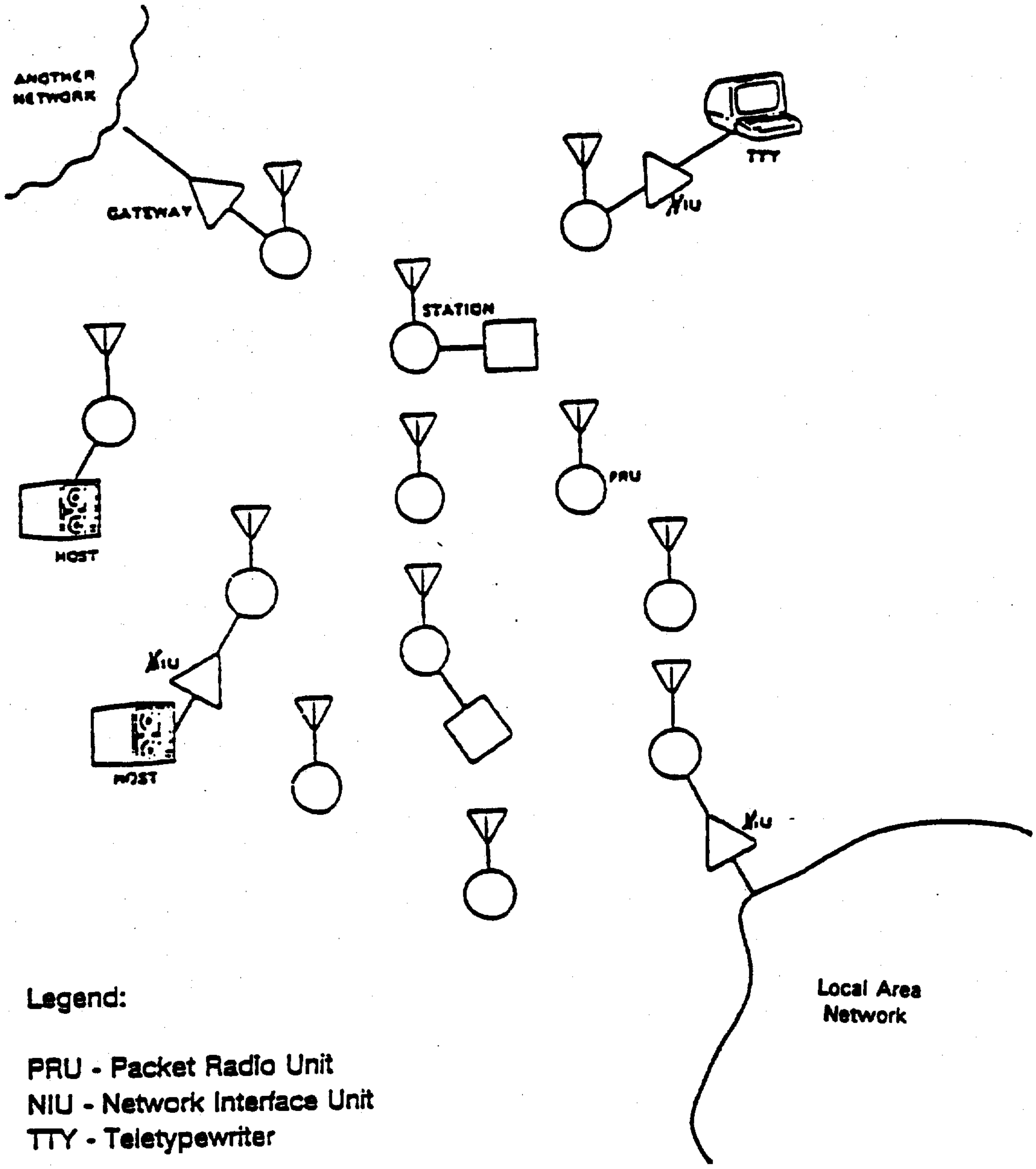
MOBILE SERVICE

Packet Radio System (PRS)

Currently, four types of PRSs have been granted assignments in the band. The majority of the PRSs are still in their experimental stages, except for the Air Force's Sprint Packet Radio which is listed in the GMF as having three types of station classes namely; fixed, aeronautical, and aircraft. This system operates at Offutt AFB, Nebraska, on the frequency 1833.9 MHz. Its technical parameters are similar to the experimental systems, except for the emission classification symbol where F7D was specified as opposed to F9W for the experimental systems. The other PRSs, Defense Advanced Research Projects Agency and Collins Packet Radios (DARPA and Colpacket radios), are undergoing experimental testing at the following locations: New York and North Carolina, respectively. Each has one assignment, 1833.9 MHz (DARPA Packet radio) and 1821.1 MHz (Colpacket radio), in the GMF. The fourth type, Hazeltine Packet Radio (Hazpacket radio), with eight assignments distributed anywhere within the 1731-1770 MHz frequency range, is in the experimental developmental stage and now becoming the testbed and demonstration system for various packet switching communication studies. A representative system and operational descriptions of these systems are presented in subsequent paragraphs.

A packet radio network (PRN) system consists of a mini-computer controller or microprocessor called a station, one or more repeaters or network interface unit (NIU), and user terminals (e.g., teletypewriter or host computer). At random times the terminals transmit a short packet of data on the order of 10 ms. The messages, which are multiplexed by code, are retransmitted by the repeater(s) and answered by the station. The repeater(s) acts as the network interface unit which provides interface between data terminals, local area networks or various host computers (e.g., PLRS/JTIDS).

Figure 5-7 is a generalized structural model of a PRN showing the components needed for an operational network. Depending upon the size of the network, there may be several stations in any one network both for network management and survivability. The actual size and specific architecture of any one particular packet radio network depends on the specific scenario, mission, or need of the user. The size of any one network may vary from several square kilometers to several hundred square kilometers; distance between radios may be from less than one km to more than 10 km, depending on the terrain and connectivity characteristics. A large percentage of the radios in the network may be unattended repeaters. The various nodes in the network communicate with one another in a broadcast or receiver directed mode utilizing spread spectrum signaling with an approximate 20 MHz bandwidth, 10 watts of power, and 9 dBi antenna gain.



Legend:

PRU - Packet Radio Unit
NIU - Network Interface Unit
TTY - Teletypewriter

Figure 5-7. Generalized structural model of a Packet Radio Network.

TETHERED RADAR BALLOONS/SEEK SKYHOOK

This system generally consists of two aerostats (tethered balloon platforms) located up to 15,000 ft. above the ground along with its associated ground support equipment. The aerostats (one active and one on standby) provide an airborne platform for surveillance radars used for air defense. Various radio links support the aerostats as indicated in Figure 5-8, including radar data downlinks on the frequencies 1720, 1755 and 1820 MHz. These links relay the radar data to ground for processing. Key technical parameters of these links include 2 watts transmitter power, 12 MHz or 60 MHz emission bandwidth, and 7 dBi and 20 dBi for the airborne and ground antenna gains, respectively. The aerostats are tracked manually.

The Department of Treasury (T) also employs numerous frequencies in these bands for up and down command and control links used with a series of tethered aerostat radar balloons along the US/Mexico border in Arizona and New Mexico as well as the Caribbean area. Several more are currently being implemented on the Gulf Coast areas of Alabama and Florida.

Air-to-Ground (A/G) Video Links

A number of air-to-ground video links are operated in this band and employed primarily for military test operations. The systems primarily provide real-time television displays from airborne cameras for ground reception. Functions include testing of remotely piloted vehicles and drones, flight testing of new aircraft, airborne monitoring of civil disturbances, and monitoring of ordnance scoring. Locations of these systems are somewhat diverse but the majority are on the military test ranges. The transmit power of these systems varies from 5 to 25 watts. The antenna gains are typically 0 dBi and 25 dBi for the airborne and ground antennas, respectively. The largest variation among the systems is in the reported emission bandwidth which varies from 1 to 35 MHz or larger. A typical bandwidth for a conventional 525 line monochrome signal, which many of these systems do employ, is approximately 16.4 MHz (4.2 MHz baseband and 4 MHz peak deviation).

The two most common emission types employed for the A/G video link operations in the low-band are frequency modulation using a single channel containing an analog signal for television (F3F) and frequency modulation using a single channel containing quantized or digital signals without the use of a modulating subcarrier for television (F1E). The latter type of emission excludes time-division multiplex. The overall usage of each of these systems is

TETHERED AEROSTAT/SURVEILLANCE RADAR SYSTEM (FIXED LAND BASED)

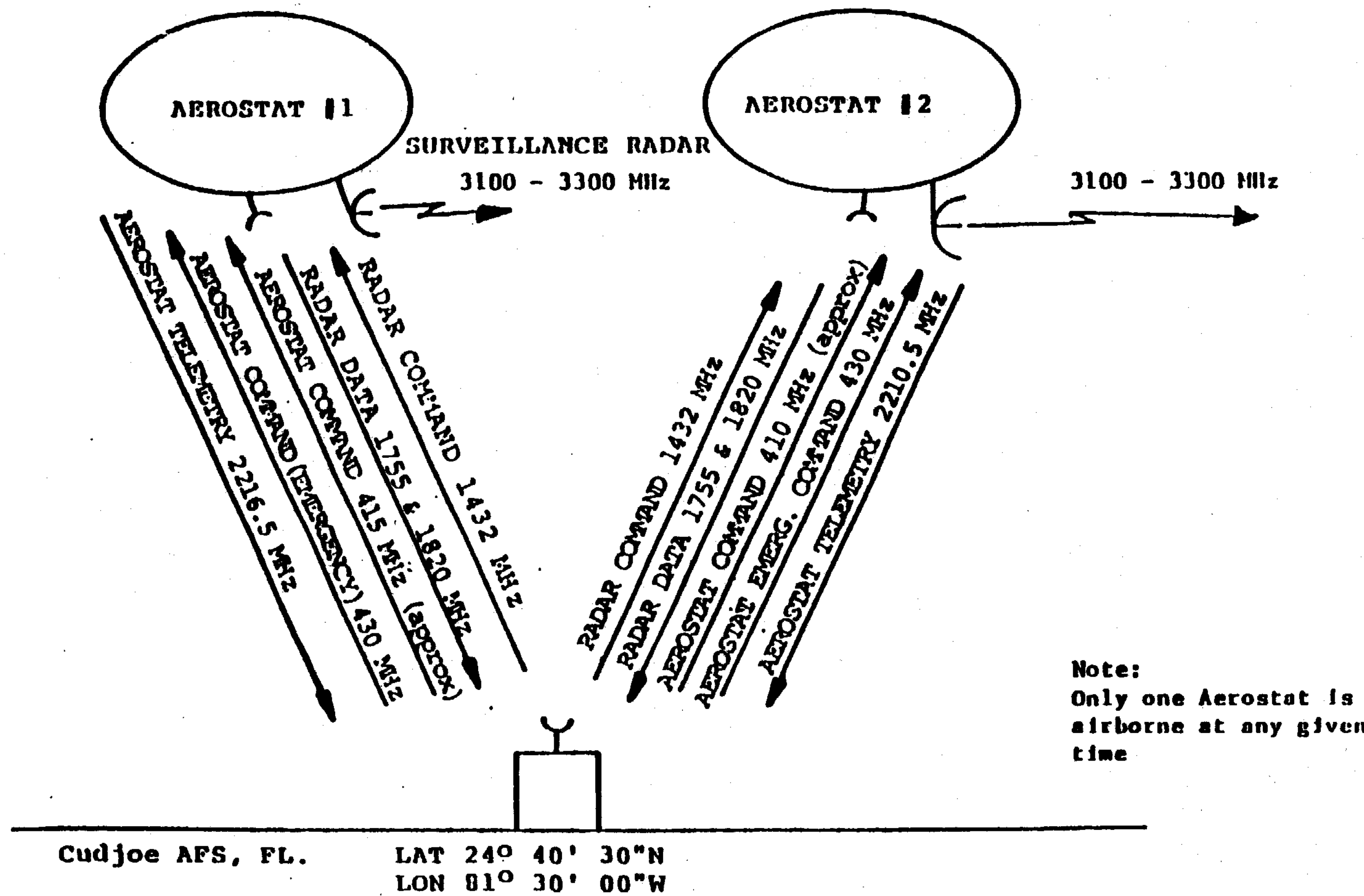


Figure 5-8. SEEK Skyhook line diagram.

expected to be intermittent and quite low. The frequencies used by the various systems are, in general, all different and are distributed somewhat evenly across the band.

Air Combat Maneuvering Instrumentation (ACMI)

Four different system names are found in the assignment records for a single generic type of equipment produced for the military. These are the Air Force's Air Combat Maneuvering Instrumentation (ACMI) and Air Space Position Measuring System (ASPMS) and the Navy's Air Combat Maneuvering Range (ACMR) and Tactical Aircrew Combat Training System (TACTS). The latter, which is the upgrade version of the ACMR, will be discussed separately. These systems are used to speed up and enhance aerial combat training activities. They provide altitude, location, velocity, and other data on up to 20 aircraft, eight high activity targets, and 12 low activity targets. Training support systems such as these are key elements in the military's efforts to provide realistic tactical simulation and pilot training in a peacetime environment.

Basically, the system uses continuous phase shift modulation (CPSM) to exchange information between remotely located ground interrogator stations and a pod-mounted transponder on the aircraft. The remote stations are, in turn, tied into a central master control station via radio links. The signals sent from the aircraft include the aircrafts' indicated airspeed, altitude, angle of attack, missile firings, etc. In the range control center, these data are recorded and projected on large TV displays. The data can also be projected on a simple display in selected aircraft. The geographical area of coverage for these systems is up to 40 miles in diameter and they may remain in operation for up to 10 hours a day.

Radio links required for the system, as illustrated in TABLE 5-6, include separate frequencies for each remote station to the master station along with three common frequencies for the master-to-remote, air-to-ground, and ground-to-air links. The major difference between the Air Force and Navy systems lies with the number of remote stations: seven for the former whereas the Navy ACMR includes one of the remote stations collocated with the master thus eliminating one radio link. The systems thus employ 9 or 10 radio frequencies, all in the 1710-1850 MHz band. These have been factory preset to the frequencies indicated on TABLE 5-6 for all systems. One exception has been the near collocation of an ACMR and ACMI in Arizona where the alternate scheme indicated is used at the Gila Bend ACMI site.

TABLE 5-6

RADIO LINK REQUIREMENTS FOR THE ACMI/ACMR

System Component	Frequencies (MHz)	
	Primary	Alternate
Master to Remotes	F_1 = 1779	1764, 1769
Remotes to Master	F_2 = 1801, 1807, 1812, 1818, 1823, 1829, 1834	1797, 1802, 1808 1813, 1819, 1824
Remotes to Aircraft (pod)	F_9 = 1840	1830
Aircraft (pod) to Remotes	F_{10} = 1788	1778

The systems are operational or planned for operation in the following locations and the number of sites is expected to continue to increase.

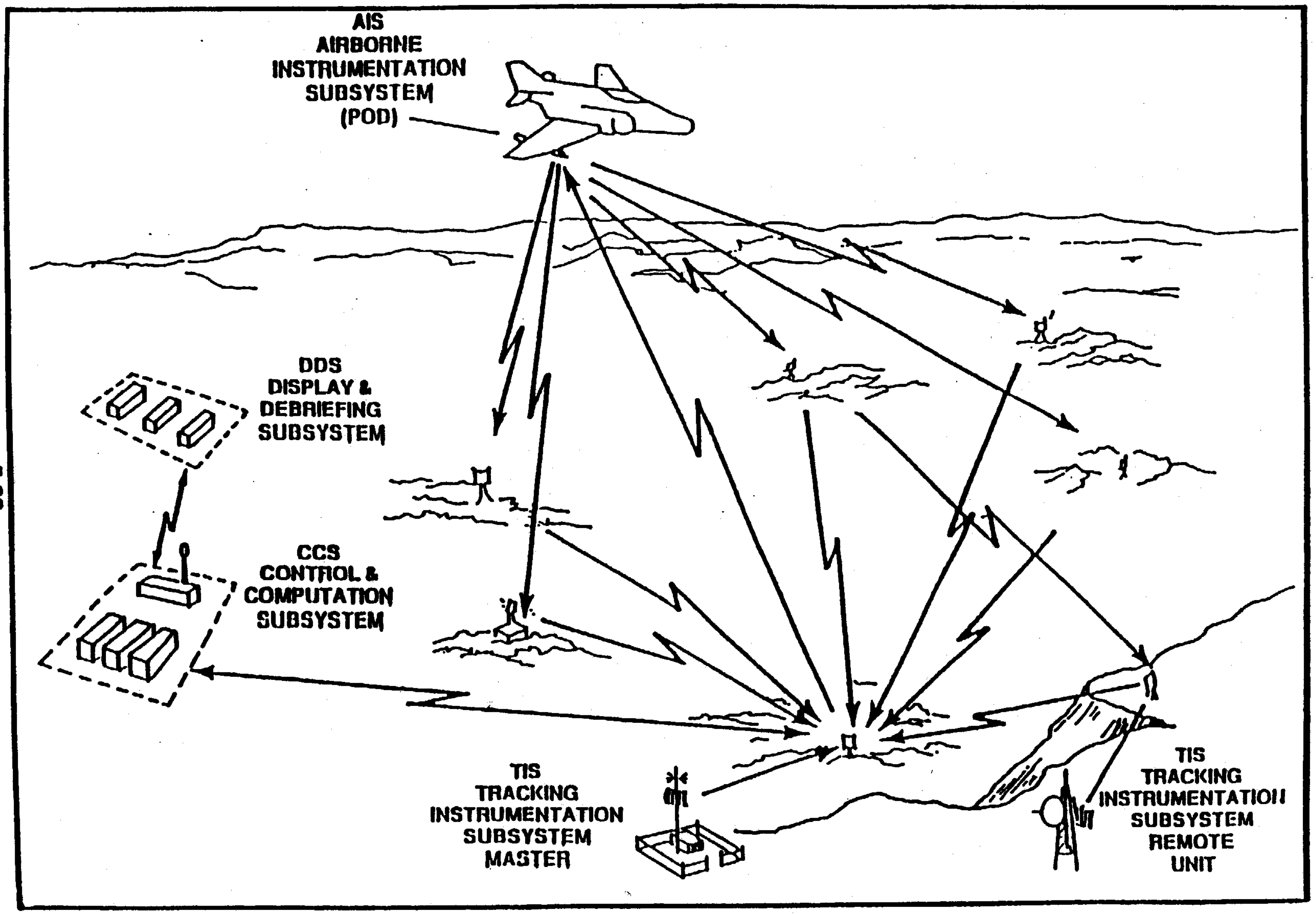
<u>ACMI</u>	<u>ACMR</u>	<u>ASPMS</u>
Nellis AFB, NV	Yuma, AZ	Wright Patterson AFB, OH
Tyndall AFB,FL	Bodie Island, NC	
Gila Bend, AZ	Charleston, SC	
Holloman, NM	Pincastle, FL	
Seymour Johnson, NC	China Lake, CA	
McDill AFB, FL	Patuxent River NAS, MD	
Hill AFB, UT	Fallon, NV	
Ft. Irwin, CA	Worldwide on 6th and 7th Fleets	
Volk Field, WS	Oceana NAS, VA	
Gulfport, MS		
Homestead AFB, FL		
Eielson AFB, AK		

Tactical Aircrew Combat Training System (TACTS)

The TACTS is used to train aircrews in air warfare operations and maneuvers without actually firing the weapons. This system can monitor aircraft closing velocity, various slant ranges, aspect angle, attitude, and acceleration. It is used as an aid in such training exercises as gun scoring, no-drop bombing, evasion and intercept tactics, and electronic warfare.

The TACTS primarily consists of the following subsystems: the Control Computational Subsystem (CCS), the Display and Debriefing Subsystem (DDS), the Tracking Instrumentation Subsystem (TIS), and the Airborne Instrumentation Subsystem (AIS). The DDS and CCS, which control the entire TACTS operation, are usually located on the base. Commands and real-time mission data are exchanged between the CCS and the TIS master stations via a data relay system. The remote TIS stations, which are spread out over a test range, are located within line-of-sight of the master TIS station. The remote TIS maintain an uplink and downlink communication with the airborne element of the TACTS, known as the AIS. The AIS is a missile-shaped, dual frequency pod that is carried under the wings of up to 36 participating aircraft. It provides inputs fundamental to the operation of the other subsystems, including weapons status monitoring information, aerological and inertial reference data, and ranging information from the training aircraft to the TIS via an air-to-ground radio frequency (RF) link. These inputs are processed by the TIS and transferred to the CCS where the aircraft position and other parameters are computed. These calculated data are transmitted to the DDS for display and use by the range training officer during real-time or post-flight instructions. Figure 5-9 illustrates how the subsystems in a basic TACTS configuration interact with each other. A TACTS range may have more than one master station and up to 28 remote TIS (e.g., Fallon NAS TACTS).

The frequency plan for the TACTS calls for all TIS and AIS frequencies to be in the 1710-1850 MHz band. TABLE 5-7 lists the frequency usage for both the Fallon and Charleston Naval Air Stations (NAS) TACTS operation. The other TACTS ranges operate either on the "A" set or "B" set frequencies, as seen in TABLE 5-7.



Note: All RF links are two-way links.

Figure 5-9. Typical configuration of a TACTS deployment.

TABLE 5-7

FALLON AND CHARLESTON NAS TACTS FREQUENCY USAGE

Type of Link	Proposed Frequencies (MHz)
Master-to-Remote	1768
AIS Pod-to-Remote (Downlink)	1788 A-Pod, 1778 B-Pod
Remote-to-Master	1797, 1802, 1807, 1812, 1817, 1822
Remote-to-AIS Pod (Uplink)	1840 A-Pod, 1830 B-Pod

All master-to-remote links use the same frequency, while each remote-to-master link is assigned its own separate frequency. In any TACTS range, a remote station is always collocated and hardwired directly to a master station.

Scoring Systems (Telemetry Links)

The systems to be discussed below include those that are primarily used to provide positional information to the user (radiolocation). The systems, however, include components that perform telemetry operations which are of concern in this report and are included here for discussion. The radiolocation functions in this band are not in accordance with the U.S. or International Radio Regulations.

A number of diverse systems have been developed and operated by the military in this band for the purpose of electronically measuring target hit or miss distance information and relaying the data to a central control point. The radio link involved in the measurement of the scoring information would be radiolocation as defined by the NTIA Manual [1990] whereas the relay link would be defined as telemetry.

Developed scoring systems may be categorized into narrowband and wideband systems. The narrowband scoring systems operate with 5 watts of power or less and a bandwidth of 2.5 MHz or less. The GMF identified five types of narrowband systems with the following names: Shell Scoring, Miss Distance Indicator (MDI), Shell Scoring Observer Communication, Straffing Target Scorer, and Miss Distance Telemetry Systems. The GMF also identified four wideband scoring systems with emission bandwidths equal to 50 MHz or greater and a power range of 1 milliwatt to 225 watts. They are listed in the GMF as: Missile Scoring, DIGIDOPS Scoring, Test Range Scoring, and Vector MDI (VMDI) Systems. These systems are operated by the Air Force and Navy at numerous bases and test ranges. The systems appear to employ pre-set fixed frequencies which are principally between 1710 and 1800 MHz.

The VMDI which may still be in the experimental stage, together with other scoring systems identified in the System Review Documentation as being either in the conceptual or experimental stage, will be discussed briefly and separately in subsequent paragraphs. Included in this category are the following systems: Bullet Hit Indicator (BHI), and the Navy's Floating at Sea Target (FAST) Scoring Systems.

Vector MISS DISTANCE Indicator (VMDI)

The VMDI is an airborne target mounted missile scoring system designed to provide missile to target range and/or angle data through pulse doppler techniques. Scoring information is transmitted to the ground station via the target's existing telemetry link. It operates with an emission bandwidth of 100 MHz and at a power of up to 225 watts. Supposedly, two versions of the VMDI have been developed for use with the PQM-102 type drone and the High Altitude Supersonic Target (HAST). The system transmits on 1800 MHz and will be used primarily over the Gulf of Mexico during the developmental stage. Because of their wide bandwidths and radiolocation function, the SPS approved spectrum support for the VDMI systems with certain restrictions but will require justification for further development in the 1710-1850 MHz band.

Bullet Hit Indicator (BHI)

The BHI is a bullet scaler scoring system and is designed to be mounted in aerial towed gunnery targets to count the number of bullets passing through a scoring volume. The data are relayed to a display in the towing aircraft. The two competitive designs both employ pulse doppler techniques for scoring but use different design specifics. The Cartwright Engineering, Inc., proposal calls for a 0.5 watts (1.25 μsec pulse) and 2 watts (153 nsec pulse) of power for the data transfer and radar set operations, respectively. The two pulses correspond to a 5.6

MHz (1.25 μsec pulse) and 34.4 MHz (153 nsec pulse) occupied bandwidth. Whereas Motorola, Inc., proposes 1 watt of power with a 500 kHz occupied bandwidth. Although both proposals were originally in the 1710-1850 MHz band because of SPS action, only the Motorola Telemetry Link is proposed to use this band for experimentation. For the developmental stage, the SPS recommended frequency bands preferred other than the 1710-1850 MHz band.

The MDI will use either a CW or pulse type modulation. Scoring data from the MDI is telemetered to the ground station in the form of a phase-modulated signal on one of 10 frequencies within the 1485-1535 MHz or 2200-2290 MHz band. TABLE C-4 (Appendix C) lists the operating characteristics of the proposed developmental AN/USQ-X Scoring System MDI.

Floating At SEA Target (FAST)

The FAST Scoring Set - Data Link is at its conceptual stage. The system is envisioned to be a stand alone system that is portable and stored until required for use. The purpose of the FAST data link is to telemeter data to scoring ships. The target set, for detecting the water impact of Naval ordnance, will be battery powered and attached to the MK-42 MOD 0 target. During fleet training exercises in the open ocean, a MK-42 MOD 0 FAST target will be used for target practice. Naval shells of 76 mm and larger diameters will be tried at the target while MK-76 and 106 bombs will be dropped at the target by Naval aircraft. Sensors such as passive hydrophones, radar lasers, etc., placed on or near the target will detect the shell and bomb water impact. The data will be transmitted to a scoring ship where it will be processed and miss distance will be displayed. The scoring ship will be within five miles of the target. Only single events (one shell or one bomb) will be scored within a 15 second period.

Ten frequency bands are being considered as potential candidates for operation of the system. Two of the frequency bands are the 1710-1850 MHz and 2200-2290 MHz. The operating characteristics of the proposed system are not yet specified at this time.

RADIO ASTRONOMY SERVICE

Radio astronomy observations are carried out at several facilities in the U.S. and elsewhere on the spectral line due to the hydroxyl radical (OH) at a rest frequency of 1720.530 MHz. In the U.S. these observations are currently on an unprotected basis, however, via Footnote US256, agencies which operate nearby these observations are encouraged to minimize potential interference insofar as it is practicable.

One such system currently employed or planned for employment for basic research in radio astronomy is the Very Long Baseline Array System (VLBAS). Some applications of the system are for mapping, measurement of relative positions and motions of sources, spacecraft tracking, measurement of polar motions and others. Eight locations in CONUS and one location each in Puerto Rico and Hawaii are designated as sites for the VLBAS.

EXPERIMENTAL

There are approximately 172 experimental assignments in the GMF that operate in the band. The majority of these assignments (160) belong to the military. A number of these assignments are for stations used for evaluation or testing of electronic equipments or systems in a design or development stage (station class symbol XC or XD). The systems represented by such assignments have, to the extent possible, been previously discussed under the appropriate service category. A second class of experimental assignments (designated XR or XT) are indicative of stations used in basic research or for evaluation or testing of electronics equipment or systems which have been developed for operational use. This latter category includes such activities as site selection, transmission path surveys, pre-delivery factor checkout, and antenna calibration. This class of assignments would not normally include any new systems that may eventually be competing for operational spectrum support with other band occupants. These assignments are all on a secondary basis and have a specified expiration date. The largest number of assignments in this class included testing of SGLS components and antenna calibration.

SECTION 6
SUMMARY OF MAJOR UNCLASSIFIED SYSTEMS IN THE 2200-2290 MHz BAND

INTRODUCTION

The sources of data cited in Section 5 of this report were used to identify the major unclassified systems currently operating or planned for operation in the 2200-2290 MHz band. The data were examined and determined that some of the systems discussed in Reference 4 are still in operation as of June 1990. The functional description, as well as the technical parameters, of these systems were derived from Reference 4. For the rest of the systems, the major sources of information used were the System Review Group (NTIA) documentations, Reference 8, and other publications (e.g., Aviation Week and Space Technology).

GENERAL

The spectrum allocation rules and regulations applicable to the 2200-2290 MHz band also permit a wide variety of systems to operate in the band which includes fixed, mobile, and space systems. In addition to those specifically permitted by the allocation tables, a number of experimental and special purpose stations have also been identified as operating in the band.

The technique used to summarize the variety of systems in the band is similar to the method previously discussed in Section 5 of this report. A summary list of the major unclassified systems, identified to date, operating or planned for operation in the 2200-2290 MHz band is shown in TABLE 6-1. Again, an estimate of the Federal Government's investment (i.e., initial and replacement costs) in the band is included in the table. Similar procedure, as in Chapter 5, is applied to calculate the replacement cost.

Since the type of services allowed in the 1710-1850 MHz and 2200-2290 MHz bands are similar, Figure 5-1 is a close representation of major systems in the environment for both bands except for some major systems that operate in the 2200-2290 MHz band but not in the 1710-1850 MHz band. These systems are the TDRSS and upgrades, Space Station, SDI, Target Satellite System and tethered satellite networks. Several of the key parameters of the major systems in the band which include frequency, power, environment of operation and others is given in TABLE 5-2.